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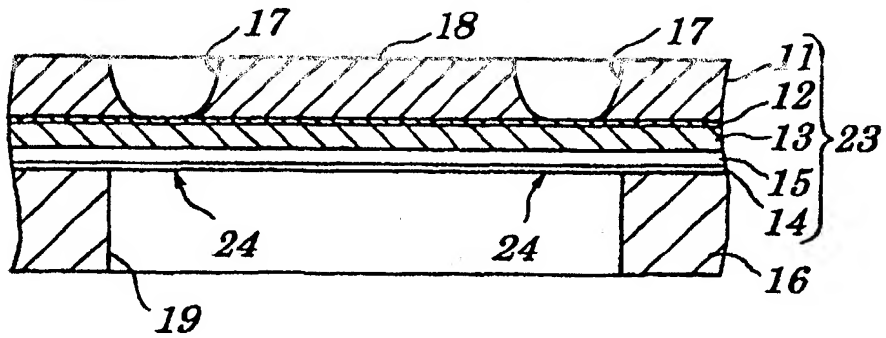
(54) Ink jet recording head and method for manufacture the same

(57) An ink jet recording head (55) may improve the packing efficiency of the ink into the pressure generating chamber (19), and improve the ejection efficiency of the ink through the ink ejection nozzle (41) to realize a high quality gradation expression in printing operations. The recording head (55) comprises: a pressure generating chamber (19) communicating with an ink reservoir (40); a vibrating plate (23) which faces the pressure generating chamber (19) and is provided with an island-like convex portion (18); and, a piezoelectric element (20) arranged so as to be brought into contact with the island-like convex portion (18) of the vibrating plate (23) to vibrate the plate (23), and thereby forcing ink droplets to be ejected from the nozzle (41). The vibrating plate (23) comprises: a first metallic layer or stainless steel member (11) brought into contact with the piezoelectric element (20), a second metallic layer or thin nickel film(15) exposed to the pressure generating chamber (19), and a polymer film (13) of a high polymeric organic compound interposed between the first metallic layer (11) and the second metallic layer (15). The island-like convex portion (18) of the vibrating plate (23) is formed by etching a surface of the first metallic layer (11).

FIG.4E



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an ink jet recording head used in an ink jet recording apparatus such as ink jet printers or like recording apparatuses, and also relates to a method for manufacturing such the ink jet recording head, wherein, in operation, the ink jet recording head records an object, for example such as characters, images, patterns or the like on a recording medium or sheet by ejecting ink droplets from an ink ejection nozzle of the ink jet recording head to realize a high quality gradation printing operation.

2. Description of the Related Art

[0002] Of various types of recording methods, a non-impact recording method is a favorable one since it is substantially free from any noise in recording operation. In recent years, use of such non-impact recording method in numerous applications has dramatically increased. Consequently, such non-impact recording method shows a wide variation in types. Of these types of the non-impact recording method, an ink jet recording method is advantageous in that: it is capable of directly recording any desired characters, images, patterns or the like on a recording medium or sheet at high recording speed through an ink jet recording apparatus with a simple construction in which the ink jet recording method is carried out; and, further, it is also capable of using ordinary paper as its recording medium or sheet, and therefore extremely easy to use.

[0003] Heretofore, various types of ink jet recording methods have been proposed, one of which is well known and carried out by the ink jet recording apparatus or printer. In such ink jet recording apparatus or printer, ink droplets are ejected from an ink ejection nozzle of an ink jet recording head thereof to adhere to the recording medium such as paper, sheets or the like, so that desired characters, images, patterns or the like are recorded on such recording media. This type of ink jet recording method is advantageous in that it is capable of: performing its recording operation at high speed; and, using ordinary paper as its recording medium without having such ordinary paper treated through a special fixing treatment in a recording operation. Heretofore, numerous forms of ink jet recording apparatuses or printers for carrying out above-mentioned ink jet recording methods have been proposed and commercially manufactured.

[0004] The ink jet recording methods are substantially classified into three major types: namely, a continuous ejection type; an on-demand type; and, an electrostatic absorption type. In the on-demand type ink jet recording method, a piezoelectric element of the ink jet recording apparatus for carrying out the on-demand type method is energized only at a predetermined moment or time when it is required, so that the ink droplets are ejected from the ink ejection nozzle of the ink jet recording apparatus at the above predetermined moment. As a result, the ink jet recording apparatus or printer for carrying out the on-demand type ink jet recording method is improved in ink consumption properties, and very simple in construction. Therefore, it is to be expected that such an on-demand type ink j et recording apparatus or printer will be widely used.

[0005] In this on-demand type of the ink jet recording apparatus, its conventional type ink jet recording head is constructed of: a pressure generating chamber which communicates with an ink reservoir; the ink ejection nozzle which communicates with the pressure generating chamber; a vibrating plate which forms a portion of the pressure generating chamber; and, the piezoelectric element which causes the vibrating plate to vibrate to intermittently increase pressure in the interior of the pressure generating chamber to produce a pressure pulse therein, wherein such a pressure pulse forces the ink of the pressure generating chamber to be ejected through the ink ejection nozzle outward and formed into the ink droplets.

[0006] Conventional on-demand type ink jet recording heads and conventional methods for manufacturing the conventional on-demand type ink jet recording heads are disclosed in both Japanese Patent Laid-Open No. Hei 8-187868 (hereinafter referred to as a first conventional example) and PCT publication No. W093/25390 (hereinafter referred to as a second conventional example). Each of the conventional ink jet recording heads disclosed in the first and the second conventional examples is constructed of: a pressure generating chamber which communicates with an ink reservoir; an ink ejection nozzle which communicates with the pressure generating chamber; a vibrating plate which forms a portion of the pressure generating chamber; a predetermined portion of the vibrating plate is formed into an island-like convex portion; and, a piezoelectric element which causes the vibrating plate to vibrate to intermittently increase the pressure in an interior of the pressure generating chamber to produce a pressure pulse therein, wherein such a pressure pulse forces ink of the pressure generating chamber to be ejected through the ink ejection nozzle outward and formed into ink droplets adhering to a recording medium or sheet. In the ink jet recording head having the above construction, the vibrating plate is constructed of a sheet member or oriented film, which is made of a high polymeric organic compound. On the other hand, the island-like convex portion of the vibrating plate is formed by etching a thin metallic plate having been bonded to the oriented film or the sheet member.

[0007] Problems to be solved by the present invention are as follows: namely, in the first and the second conventional examples both mentioned above, the sheet

member or oriented film made of the high polymeric organic compound which is highly water-repellent is brought into contact with the ink received in the pressure generating chamber. Due to this, the ink received in the pressure generating chamber tends to be pushed away from such the highly water-repellent sheet member or oriented film of the high polymeric organic compound, which makes it impossible for the ink to be properly filled or packed into the pressure generating chamber. In this case bubbles tend to be produced in the ink in the pressure generating chamber. Once bubbles are formed in the ink of the pressure generating chamber, the pressure pulse produced by the piezoelectric element is transmitted to the ink of the pressure generating chamber, and then absorbed by bubbles in the ink of the pressure generating chamber, which makes it impossible for the ink of the pressure generating chamber to be properly ejected from the ink ejection nozzle, and thereby impairing a print in quality or in gradation expression.

[0008] Further, in the first and the second conventional examples described above, since it is difficult to control in depth a plurality of thin-walled peripheral portions of the island-like convex portions of the vibrating plate in the etching operation, i.e., since it is difficult to control in thickness these thin-walled peripheral portions of the vibrating plate in the etching process, the individual island-like convex portions of the vibrating plate in which each of the island-like convex portions is surrounded by the thin-walled peripheral portion and differ from each other in frequency of vibration when vibrated by the piezoelectric element, which often varies the quality of the print in an individual channel or in an individual lot. Further, in such a production process (i.e., such an etching process), the thin-walled peripheral portions of the island-like convex portions of the vibrating plate are exposed to an etching agent, which impairs physical properties or mechanical strength of the vibrating plate.

SUMMARY OF THE INVENTION

[0009] In view of the above, it is an object of the present invention to provide an ink jet recording head and a method for manufacturing it, which are capable of: enhancing the packing efficiency of an ink received in a pressure generating chamber; improving the ejection efficiency of the ink ejected from an ink ejection nozzle; and, thereby realizing high quality gradation expression in recording or printing operations.

[0010] It is another object of the present invention to provide an ink jet recording head and a method for manufacturing it, which are capable of: accomplishing the above objects of the present invention; controlling in thickness a thin-walled peripheral portion of each of island-like convex portions of a vibrating plate in an easy manner; preventing such thin-walled peripheral portion from being exposed to an etching agent in an etching process; and, thereby providing the vibrating plate to have sufficient mechanical strength.

[0011] According to a first aspect of the present invention, there is provided:

in an ink jet recording head comprising: a pressure generating chamber communicated with a U-shaped common ink reservoir; a vibrating plate which faces the pressure generating chamber and is provided with an island-like convex portion; and, a piezoelectric element which is so arranged as to be brought into contact with the island-like convex portion of the vibrating plate to vibrate the vibrating plate, and thereby forcing ink droplets to be ejected from an ink ejection nozzle, the improvement wherein:

the vibrating plate is provided with three layers, i.e., a first metallic layer which is brought into contact with the piezoelectric element, a second metallic layer which is exposed to the pressure generating chamber, and a polymer film which is made of a high polymeric organic compound and interposed between the first metallic layer and the second metallic layer; and

the island-like convex portion of the vibrating plate is formed by etching a surface of the first metallic layer,

[0012] In the foregoing, the preferable mode is one wherein the polymeric organic compound of the polymer film has a molecular weight of more than or equal to 10^3.

[0013] In the above construction, since the second metallic layer serving as an inner surface of the pressure generating chamber is brought into direct contact with the ink received in the pressure generating chamber, it is possible for the second metallic layer to use its hydrophilic properties in having the ink brought into intimate contact with the vibrating plate, which improves the packing or filing efficiency of the ink in the pressure generating chamber, and thereby preventing bubbles from being formed in the ink. Consequently, it is possible for the ink jet recording head of the present invention to solve a problem inherent in the conventional ink jet recording head in which a pressure pulse issued from the piezoelectric element to the pressure generating chamber is absorbed by the bubbles formed in the ink. As a result, the ink jet recording head of the present invention is capable of keeping its ink ejection operation steady and stable to realize a high quality gradation expression in recording or printing operations.

[0014] Also, the preferable mode is one wherein the first metallic layer and the polymer film are bonded to each other through the adhesive layer. In this case, in forming the island-like convex portion in the vibrating plate, the etching process stops when the adhesive layer interposed between the first metallic layer and the polymer film of the high polymeric organic compound is encountered, which makes it easier to control the thickness of the thin-walled peripheral portion surrounding the island-like convex portion in the vibrating plate. Fur-

ther, it is also possible for the ink jet recording head of the present invention to avoid the disadvantage that the thin-walled peripheral portion of the island-like convex portion is exposed to the etching agent used in the etching process.

[0015] Also, the preferable mode is one wherein the second metallic layer is formed on the polymer film by a sputtering process or by a vapor deposition process. In this case, it is possible to form the second metallic layer in an easier manner compared with the case that the second metallic layer is separately formed and then bonded to the polymer film.

[0016] Further, the preferable mode is one wherein the first metallic layer is made of a stainless steel. In this case, a rolled steel or stainless steel is generally used. This rolled steel is etched by the etching agent such as ferric chloride or the like to produce the island-like convex portion with a forming accuracy in level or height on the order of approximately ± 1 μm. Further, as for the adhesive layer, it may be formed of any one of various types of adhesives, for example such as epoxy-based adhesives or like, wherein these adhesives are capable of hardening or setting at a relatively low temperature. In other words, in the ink jet recording head of the present invention, the adhesive used in the adhesive layer may have a wide variation of alternatives, and therefore be able to be any desirable one of such alternatives.

[0017] More specifically, the preferable mode is one wherein the second metallic layer is made of nickel. In this case, the second metallic layer of nickel is produced by a conventional layer forming process such as the sputtering process or the vapor deposition process, and has a thickness of from approximately 0.1 to approximately 1 μm, which renders the second metallic layer resistant to the ink. In a bonding operation of a first plate for forming the pressure generating chamber, it is possible to select a desired adhesive in a wide range of alternatives, wherein the chamber plate is bonded through a layer of the desired adhesive, as is in the case of the first metallic layer or stainless steel layer to which the piezoelectric element is bonded through the adhesive layer. Namely, in the above case, it is possible to increase a number of choices of the adhesive which is available in bonding the components of the ink jet recording head of the present invention.

[0018] Also, the preferable mode is one wherein a silicon oxide film is formed on a surface of the second metallic layer to render the inner surface of the pressure generating chamber hydrophilic, wherein the inner surface of the pressure generating chamber is brought into contact with the ink received therein.

[0019] Further, the preferable mode is one wherein the silicon oxide film has its surface activated by a plasma radiation process performed in an oxidizing atmosphere, which further improves in hydrophilic properties the surface of the silicon oxide film.

[0020] The preferable mode is one wherein the second metallic layer has a surface thereof exposed to the pressure generating chamber, wherein the surface of the second metallic layer is subjected to the plasma radiation process, and therefore improved in its hydrophilic properties.

[0021] Also, according to a second aspect of the present invention, there is provided:

> in the ink jet recording head comprising: the pressure generating chamber communicated with the ink reservoir; a vibrating plate which faces the pressure generating chamber (19) and is provided with the island-like convex portion; and, the piezoelectric element which is so arranged as to be brought into contact with the island-like convex portion of the vibrating plate to vibrate the vibrating plate, and thereby forcing ink droplets to be ejected from the ink ejection nozzle, the improvement wherein:
> the vibrating plate is provided with three layers, i.e., the first metallic layer having its surface brought into contact with the piezoelectric element, the polymer film which is made of the high polymeric organic compound and formed on the lower surface of the first metallic layer to have its surface exposed to the pressure generating chamber, and the silicon oxide film formed on the polymer film of the high polymeric organic compound; and
> the island-like convex portion of the vibrating plate is formed by etching the surface of the first metallic layer.

[0022] In the foregoing, since the silicon oxide film is brought into contact with the ink received in the pressure generating chamber, it is possible to advantageously use the hydrophilic properties of the silicon oxide film in introducing and filling the ink into the pressure generating chamber, and also in having the vibrating plate brought into intimate contact with the ink received in the pressure generating chamber.

[0023] The preferable mode is one wherein the silicon oxide film has its surface activated by the plasma radiation process performed in an oxidizing atmosphere, which makes it possible to further improve the surface of the silicon oxide film in its hydrophilic properties.

[0024] Also, according to a third aspect of the present invention, there is provided:

> in a method for manufacturing the ink jet recording head comprising: the pressure generating chamber communicated with an ink reservoir; the vibrating plate which faces the pressure generating chamber and is provided with the island-like convex portion; and, the piezoelectric element
> which is so arranged as to be brought into contact with the island-like convex portion of the vibrating plate to vibrate the vibrating plate, and thereby forcing ink droplets to be ejected from the ink ejection nozzle, the improvement which comprises:

a bonding step for bonding the first metallic layer and the polymer film to each other, wherein the first metallic layer is brought into contact with the piezoelectric element

while the polymer film is made of the high polymeric organic compound to form part of the thin-walled portion in the peripheral portion of the island-like convex portion of the vibrating plated

an island-like convex portion forming step for forming the island-like convex portion of the vibrating plate by etching the first metallic layer;

a second metallic'layer forming step for forming the second metallic layer on the lower surface of the polymer film of the high polymeric organic compound to have the lower surface of the second metallic layer exposed to the pressure generating chamber , wherein the polymer film of the high polymeric organic compound has its lower surface positioned so as to be more distant from the first metallic layer compared to its upper surface;

whereby the vibrating plate is formed through the bonding step, island-like convex portion forming step, and the second metallic layer forming step.

[0025] In the foregoing third aspect, since the second metallic layer serves as a lower surface of the vibrating plate and is brought into contact with the ink received in the pressure generating chamber , it is possible to advantageously use the hydrophilic properties of the secondmetallic layer in having the vibrating plate brought into intimate contact with the ink received in the pressure generating chamber , and in filling or packing the ink into the pressure generating chamber.

[0026] The preferable mode is one wherein in the bonding step, the first metallic layer and the polymer film of the high polymeric organic compound are bonded to each other through an adhesive layer, In this case, in forming the island-like convex portion of the vibrating plate , it is possible to stop the etching process in a position where the adhesive layer exists, i.e., in a position between the first metallic layer and the polymer film of the high polymeric organic compound, which makes it easier to control in thickness the thin-walled peripheral portion of the island-like convex portion of the vibrating plate , and further makes it possible to avoid the disadvantage that the thin-walled peripheral portion of the island-like convex portion is exposed to the etching agent used in the etching process, whereby a vibrating plate excellent in physical properties, more specifically, excellent in mechanical strength is obtained.

[0027] The preferable mode is one wherein in the second metallic layer forming step, the second metallic layer has a thickness of from approximately 0.1 to approximately 1 μm.

[0028] Further, the preferable mode is one wherein the second metallic layer is formed on the inner or lower surface of the polymer film of the high polymeric organic compound by the sputtering process or by a vapor deposition process. In this case, it is possible to produce the second metallic layer in an easier manner compared with production of the second metallic layer having been separately produced and then bonded to the polymer film of the high polymeric organic compound through the adhesive layer,

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] The above and other objects, advantages and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a perspective view of an ink jet recording apparatus or printer according to an embodiment of the present invention, illustrating an entire arrangement of the ink jet recording apparatus or printer of the present invention;

Fig. 2 is an exploded perspective view of an ink jet recording head of the embodiment of the present invention shown in Fig. 1;

Fig. 3 is a cross-sectional view of essential parts of the ink jet recording head of the present invention, taken along a line passing through a longitudinal axis of one of pressure generating chambers of the ink jet recording head of the embodiment of the present invention shown in Fig. 2;

Figs. 4A, 4B, 4C, 4D and 4E show a series of enlarged views of essential parts of a cross-sectional view of the ink jet recording head of the present invention, illustrating a series of corresponding assembly operations of the essential parts of the ink jet recordinghead of the present invention, wherein:

Fig. 4A is an enlarged view of the essential parts in cross section of the ink jet recording head of the present invention, illustrating a polymer film of a high polymeric organic compound bonded to a first metallic layer through an adhesive layer;

Fig. 4B is an enlarged view of the essential parts in cross section of the ink jet recording head of the present invention, illustrating an island-like convex portion and a thin-walled peripheral portion both of which are formed in the first metallic layer shown in Fig. 4A;

Fig. 4C is an enlarged view of the essential parts in cross section of the ink jet recording head of the present invention, illustrating a second metallic layer formed on a lower surface of the polymer film of the high polymeric organic compound shown in Fig. 4B;

Fig. 4D is an enlarged view of the essential parts in cross section of the ink jet recording head of the present invention, illustrating a silicon oxide film formed on a lower surface of the second metallic layer shown in Fig. 4C; and

Fig. 4E is an enlarged view of the essential parts in cross section of the ink jet recording head of the

present invention, illustrating a chamber plate bonded to a lower surface of the silicon oxide film shown in Fig. 4D.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] The best modes for carrying out the present invention will be described in detail using embodiments of the present invention with reference to the accompanying drawings.

[0031] Fig. 1 shows an embodiment of an ink jet recording head 55 of the present invention mounted on an ink jet recording apparatus or printer 43.

[0032] The ink jet recording apparatus or printer 43 shown in Fig. 1 comprises: a guide shaft 45, which laterally extends inside a main body of the ink jet recording apparatus of printer 43 and is fixedly mounted to a main body: a head carriage 52, which is driven by an appropriate driver such as stepping motor or the like (not shown) to reciprocate along the guide shaft 45; and, a control portion (not shown) for systematically controlling the ink jet recording apparatus or printer 43 in recording or printing operations.

[0033] On the other hand, the main body of the ink jet recording apparatus or printer 43 is provided with a pair of sheet feeding rollers 47, 54 for feeding a recording medium or sheet 53, wherein the sheet feeding roller 54 forms a pinch roller which is brought into press-contact with the other sheet feeding roller 47 to sandwich the recording medium or sheet 53 therebetween in feeding operation of the recording medium or sheet 53.

[0034] In an ink jet recording or printing operation of a text, for example, the recording medium or sheet 53 is intermittently fed or moved forward at predetermined printed-line intervals by the sheet feeding rollers 47, 54 in a direction indicated by the arrow "a", as viewed in Fig. 1, wherein the sheet feeding rollers 47, 54 are interlocked with the head carriage 52 in operation. As is clear from Fig. 1, disposed in front of the sheet feeding rollers 47, 54 are a plurality of sheet discharging rollers 56a, 56b and 56c by which the recording medium or sheet 53 has its rear surface supported in its recording or printing operation.

[0035] The head carriage 52 is provided with: a cartridge holder 51, mounted in which are a black ink cartridge 50 adapted for alphanumerical text printing and a color ink cartridge 49 adapted for color image or pattern printing; and, the ink jet recording head 55 for ejecting ink droplets to the recording medium or sheet 53 in the recording or printing operation.

[0036] In the recording or printing operation, the black ink cartridge 50 delivers black ink to the ink jet recording head 55. More specifically, the black ink supplied from the black ink cartridge 50 is received in a single U-shaped common ink reservoir 40 (shown in Fig. 2) which assumes a U-shaped form to communicate with a plurality of pressure generating chambers 19, as is clear from Fig. 2. In this embodiment of the present invention, each of these pressure generating chambers 19 is then filled with black ink issued from the U-shaped common ink reservoir 40 shown in Fig. 2. Under such circumstances, when ejection of ink droplets of the black ink onto the recording medium or sheet 53 is required, a corresponding one of a plurality of electrodes 22 of a piezoelectric element 20 mounted on a vibrating plate 23 is energized to have an island-like convex portion 18 of the vibrating plate 23 vibrated, which intermittently increases the pressure of an interior of a corresponding one of the pressure generating chambers 19 to produce therein a pressure pulse which gives ink discharging energy to the ink in the corresponding one of the pressure generating chambers 19. As a result, the ink thus energized in the corresponding one of the pressure generating chambers 19 is ejected outward through a corresponding one of a plurality of ink ejection nozzles 41 (shown in Fig. 2) to form ink droplets which hit and adhere to a surface of the recording medium or sheet 53, and thereby accomplishing their printing or recording purpose, wherein the corresponding one of the ink ejection nozzles 41 is communicated with the corresponding one of the pressure generating chambers 19, as is clear from Fig. 2.

[0037] On the other hand, each of a plurality of different color inks supplied from the color ink cartridge 49 enters a corresponding one of a plurality of color ink reservoirs (not shown), and passes through to fill the corresponding one of the pressure generating chambers 19. In the corresponding pressure generating chambers 19, when each of the color inks is energized through actuation of the corresponding one of the plurality of the electrodes 22 in the piezoelectric element 20, each of the color inks thus energized is ejected outward through the corresponding color ink ejection nozzles 41 to form the color ink droplets which hit the surface of the recording medium or sheet 53 and adhere thereto, so that the thus energized one of the color inks accomplishes its printing or recording purpose.

[0038] Fig. 2 shows an exploded perspective view of an essential part of the ink jet recording head 55 of the embodiment of the present invention show in Fig. 1. As is clear from Fig. 2, the ink jet recording head 55 of the present invention has a construction adapted for both the black ink cartridge 50 and the color ink cartridge 49.

[0039] More particularly, the ink jet recording head 55 of the present invention is provided with the piezoelectric element 20 which comprises: the plurality of individual electrodes 22 a number of which corresponds to that of the ink ejection nozzles 41; and, a pair of common electrodes 20a, 21 electrically connected with all the individual electrodes 22.

[0040] In an arrangement, as is shown in Fig. 3, the piezoelectric element 20 is disposed adjacent to an upper surface of the vibrating plate 23, and brought into close contact with the island-like convex portion 18 of the vibrating plate 23, wherein the island-like convex

portion 18 projects upward from a thin-walled peripheral portion 24 surrounding the island-like convex portion 18 in the vibrating plate 23, as shown in Fig. 4B. In the ink jet recording or printing operation, the ink received in the pressure generating chamber 19 is ejected from the ink ejection nozzle 41 to form ink droplets applied to the recording medium or sheet 53 (shown by a dashed line in Fig. 1). More specifically, when a desired one of the electrodes 22 in the piezoelectric element 20 is energized, the thus energized electrode 22 of the piezoelectric element 20 causes a corresponding one of the island-like convex portions 18 of the vibrating plate 23 to vibrate, which produces the pressure pulse in the corresponding one of the pressure generating chambers 19 to have the ink therein ejected through the corresponding one of the ink ejection nozzles 41 outward. In addition to the above piezoelectric element 20 and vibrating plate 23, the ink jet recording head 55 further comprises: a chamber plate 16 provided with a through-hole, wherein the chamber plate 16 has its upper surface brought into close contact with a lower surface of the vibrating plate 23, and has its lower surface brought into close contact with an upper surface of the ink supply plate 30: an ink reservoir plate 36 having its upper surface brought into close contact with a lower surface of the ink supply plate 30 and its lower surface brought into close contact with an upper surface of an ink discharging plate 42. and, the ink discharging plate 42 provided with the plurality of the ink ejection nozzles 41, as shown in Fig 3

[0041] In construction, as is clear from Fig. 2, the vibrating plate 23 is provided with an inlet port 25 in its outer peripheral portion, and serves as a vibrating means for transmitting a displacement of the piezoelectric element 20 as a pressure pulse to the ink received in the pressure generating chamber 19.

[0042] On the other hand, the chamber plate 16 is provided with: an inlet port 29 which communicates with the corresponding inlet port 25 of the vibrating plate 23; and, a plurality of the pressure generating chambers 19 which communicate with the U-shaped common ink reservoir 40, wherein each of the pressure generating chambers 19 is constructed of each of a plurality of the through-holes of the chamber plate 16, and these through-holes are arranged in a pair of rows arranged parallel to each other, as shown in Fig. 2.

[0043] As is clear from Fig. 2, ink supply plate 30 is provided with: an inlet port 35 which communicates with the corresponding inlet port 29 of the chamber plate 16; a plurality of ink inlet passages 32 arranged in a pair of rows arranged parallel to each other, wherein each of these ink inlet passages 32 communicates with a corresponding one of the pressure generating chambers 19 of the chamber plate 16 and disposed in the upstream side of such a corresponding one of the pressure generating chambers 19, as is clear from Fig. 3; and, a plurality of ink outlet passages 33 arranged in a pair of rows arranged parallel to each other, wherein each of these ink outlet passages 33 communicates with a corresponding one of the pressure generating chambers 19 of the chamber plate 16, and is disposed in the downstream side of such a corresponding one of the pressure generating chambers 19 so as to be disposed adjacent to a corresponding one of the rows of the ink inlet passages 32, as shown in Fig. 2.

[0044] On the other hand, formed in the ink reservoir plate 36 are: a plurality of through-passages 37, each of which communicates with a corresponding one of the ink outlet passages 33 of the ink supply plate 30, and also communicates with a corresponding one of the ink ejection nozzles 41 of the ink discharging plate 42; and, the U-shaped common ink reservoir 40, which communicates with the plurality of the ink inlet passages 32.

[0045] Disposed adjacent to the lower surface of this ink reservoir plate 36 is an upper surface of the ink discharging plate 42 which is provided with a plurality of the ink ejection nozzles 41, wherein these ink ejection nozzles 41 are arranged in a pair of rows arranged parallel to each other in a manner such that each of these ink ejection nozzles 41 communicates with a corresponding one of the through-passages 37 of the ink reservoir plate 36. In the ink jet recording head 55 of the present invention having the above construction, each of the through-passages 37 of the ink reservoir plate 36 is connected with a corresponding one of the ink outlet passages 33 of the ink supply plate 30 to form an elongated ink outlet passage, as is clear from Fig. 3.

[0046] Fig. 3 shows a cross-sectional view of an essential part of the ink jet recording head 55 of the present invention having the above construction, taken along a cutting line passing through a longitudinal axis of one of the pressure generating chambers 19 to illustrate the assembly operations of the ink jet recording head 55 of the present invention, wherein the above cutting line also passes through a central concave portion forming one common electrode 20a of a pair of common electrodes 20a, 21 (shown in Fig. 2) of the piezoelectric element 20. An individual electrode 22 of the piezoelectric element 20 is fixedly mounted on a corresponding portion of an upper surface of the vibrating plate 23. More specifically, as is clear from Fig. 2, in the piezoelectric element 20, there are formed a plurality of column portions corresponding to the individual electrodes 22, so that each of these column portions of the individual electrodes 22 are fixedly mounted on each of the corresponding island-like convex portions 18 of the vibrating plate 23.

[0047] In construction, bonded to the lower surface of this vibrating plate 23 is an upper surface of the chamber plate 16, wherein the chamber plate 16 is made of stainless steel such as SUS304 or the like steels, or made of any other suitable metals and alloys such as nickel and or the like. On the other hand, bonded to a lower surface of the chamber plate 16 thus bonded to the lower surface of the vibrating plate 23 is an upper surface of the ink supply plate 30, as is clear from Fig. 3. Further,

the ink supply plate 30 thus bonded to the chamber plate 16 has its lower surface bonded to an upper surface of the ink reservoir plate 36, as shown in Fig. 3, which also shows the ink discharging plate 42 which has its upper surface bonded to a lower surface of the ink reservoir plate 36.

[0048] In the ink jet recording head 55 of the present invention having the above construction, the chamber plate 16 is provided with the through-hole forming the pressure generating chamber 19, and has this pressure generating chamber 19 sandwiched between: the vibrating plate 23, which is mounted on the chamber plate 16; and, the ink supply plate 30, on which the chamber plate 16 is mounted. As a result, the pressure generating chamber 19 is defined by the chamber plate 16, vibrating plate 23 and the ink supply plate 30, as is clear from Fig. 3. Any one of the pressure generating chambers 19 thus defined in the above description communicates with the U-shaped common ink reservoir 40 through the corresponding ink inlet passages 32.

[0049] In printing or recording operations, any one of the black ink cartridge 50 and a plurality of different color ink cartridges 49 supplies its own ink to the corresponding ink reservoir 40 through a series of the above-mentioned inlet ports 25, 29 and 35 to fill the U-shaped common ink reservoir 40 with its own ink. The ink thus received in the U-shaped common ink reservoir 40 flows out of the U-shaped common reservoir 40 to enter the ink inlet passage 32. After that, through the ink inlet passage 32, the ink then enters the corresponding one of the pressure generating chambers 19, and flows into the corresponding ink outlet passages 33 and through passages 37. These ink outlet passages 33 and through passages 37 are from elongated passages.

[0050] As is clear from Fig. 3, in construction, the ink outlet passages 33 and through passages 37 (together forming the elongated outlet passages) gradually reduce in diameter to reach the ink ejection nozzles 41. Consequently, in operation, when the piezoelectric element 20, more specifically its individual electrodes 22 are energized through application of a predetermined electric current on the electrodes 22, the corresponding island-like convex portion 18 of the vibrating plate 23 vibrates to intermittently increase the pressure of the interior of the corresponding pressure generating chambers 19, and thereby generating a pressure pulse which causes the ink of the corresponding pressure generating chambers 19 to be ejected from the corresponding ink ejection nozzles 41 onto the recording medium or sheet 53 (shown in Fig. 1).

[0051] Figs. 4A, 4B, 4C, 4D and 4E show a series of enlarged views of essential parts of the cross-sectional view of the ink jet recording head 55 of the present invention, illustrating a series of corresponding assembly operations of the essential parts of the ink jet recording head 55 according to the embodiment of the present invention.

[0052] First, as shown in Fig. 4A, the first metallic layer 11 is formed of stainless steel (i.e., SUS), and has its lower surface bonded to an upper surface of a polymer film (i.e., oriented film) 13 of a high polymeric organic compound through an adhesive layer 12.

[0053] The high polymeric organic compound of the polymer film 13 in this embodiment of the present invention comprises, for example: polyimide (PI) resins; polyether imide (PEI) resins; polyamide imide (PAI) resins; polyparaban (PPA) resins; polysulfone (PSF) resins; polyether sulfone (PES) resins; polyether ketone (PEK) resins; polyether ether ketone (PEEK) resins; polyphenylene sulfide (PPS) resins; polyolefin (APO) resins; polyethylene naphthalate (PEN) resins; or, like resins. The high polymeric organic compound of the polymer film 13 in this embodiment of the present invention has a molecular weight of more than or equal to 10^3.

[0054] Then, as shown in Fig. 4B, an upper surface of the first metallic layer 11 is etched by a "half etching" process with the use of a predetermined etching agent or liquid, so that an annular groove 17 assuming an oval shape in plan view is formed in the first metallic layer 11, wherein a major axis of the oval shape of this annular groove 17 extends in a direction perpendicular to the plane of the paper of Fig. 4B. This annular groove 17 surrounds the island-like convex portion 18 in the first metallic layer 11 to form the thin-walled peripheral portion 24 surrounding the island-like convex portion 18. More particularly, the first metallic layer 11, its upper surface coated with a resist film, is then subjected to a photolithography process with the use of a predetermined mask pattern, and finally subjected to a developing process in the above-mentioned etching operation.

[0055] Since the first metallic layer 11 made of stainless steel and the polymer film 13 made of the high polymeric organic compound are bonded to each other through the adhesive layer 12, the etching operation performed on the first metallic layer 11 to form the thin-walled peripheral portion 24 around the island-like convex portion 18 in the vibrating plate 23 stops at an upper surface of the adhesive layer 12, as shown in Fig. 4B. Due to this, it is possible to control the thickness of the thin-walled peripheral portion 24 around the island-like convex portion 18 of the vibrating plate 23 in an easier manner, and also possible to avoid the disadvantage that the thin-walled peripheral portion 24 is subjected to the etching agent or liquid, which ensures sufficient physical or mechanical strength of the vibrating plate 23.

[0056] Further, as shown in Fig. 4C, the polymer film 13 made of the high polymeric organic compound has its lower surface coated with a second metallic layer (i.e., thin nickel film) 15 which is formed by a sputtering process or by a vapor deposition process to have a thickness of from approximately 0.1 μm to approximately 1 μm. Consequently, as is clear from Fig. 4C, the lower surface of the polymer film 13 of the high polymeric organic compound provided with water repellent properties is coated with the second metallic layer 15 constructed of the above nickel film. In this case, as de-

scribed above, since the second metallic layer 15 is formed directly on the lower surface of the polymer film 13 by the sputtering process or by the vapor deposition process, it is possible to form the second metallic layer 15 in an easier manner compared with formation of the second metallic layer 15 having been separately formed and thereafter bonded to the lower surface of the polymer film 13 through the adhesive layer 12. In addition to the above advantage, in this case, it is also possible to reduce the thickness of the thin-walled peripheral portion 24 of the vibrating plate 23, which may improve the vibrating plate 23 in efficiency of vibration.

[0057] Then, as shown in Fig. 4D, a silicon oxide (SiO_2) film 14 having a film thickness of from approximately 0.1 μm to approximately 1 pm is formed on a lower surface of the second metallic layer 15 by a plasma CVD process. Since the silicon oxide film 14 has hydrophilic properties, it is possible to use such hydrophilic silicon oxide film 14 for directly coating the inner surface of the pressure generating chamber 19 with the silicon oxide film 14. This permits the silicon oxide film 14 to be brought into contact with the ink received in the pressure generating chamber 19, and also to improve the packing (i.e., filling) efficiency of the ink into the pressure generating chambor 19.

[0058] Further, in this case, the silicon oxide film 14 has its lower surface activated by a plasma radiation process performed in an oxidizing atmosphere, which further improves the hydrophilic properties of the lower surface of the silicon oxide film 14, and therefore improves the packing efficiency of the ink in the pressure generating chamber 19.

[0059] Now, with reference to Fig. 4E, an assembly of the vibrating plate 23 will be described in construction. As shown in Fig. 4E, the assembly of the vibrating plate 23 is constructed of: the first metallic layer 11; the polymer film 13 made of the high polymeric organic compound; the second metallic layer 15 made of nickel; and, the silicon oxide film 14, wherein these components are stacked into the assembly (i.e., vibrating plate 23) in a manner such that the vibrating plate 23 is bonded to the chamber plate 16 so as to have both the annular grooves 17 and the island-like convex portions 18 precisely positioned relative to the corresponding portions of the pressure generating chamber 19. In this case, the adhesive properties of the silicon oxide film 14 having its lower surface already activated are improved relative to those of the silicon oxide film 14 still not activated in its lower surface.

[0060] Through the above processes or process steps, the assembly or vibrating plate 23 is produced by stacking together: the first metallic layer 11; the polymer film 13 made of the high polymeric organic compound; the second metallic layer 15 made of nickel; and, the silicon oxide film 14, in the thus enumerated order. In the vibrating plate 23, since the thin-walled peripheral portion 24 is formed around the island-like convex portion 18 oppositely disposed from the pressure generating chamber 19, the thin-walled peripheral portion 24 of the vibrating plate 23 serves as a diaphragm means when the piezoelectric element 20 is energized and begins to vibrate, wherein the thin-walled peripheral portion 24 is constructed of the adhesive layer 12, polymer film 13 of the high polymeric organic compound, second metallic layer 15 and the silicon oxide film 14 to transmit the pressure pulse from the piezoelectric element 20 to the island-like convex portion 18, and further to the ink received in the pressure generating chamber 19.

[0061] In packing or filling ink into the pressure generating chamber 19, when the lower surface of the vibrating plate 23 is exposed to the interior of the pressure generating chamber 19 and is poor in hydrophilic properties, the ink tends to be expelled away from the lower surface of the vibrating plate 23, which prevents the ink from being properly packed or filled into the pressure generating chamber 19. In view of the above fact, in this embodiment of the present invention, the lower surface of the vibrating plate 23 is coated with the silicon oxide film 14 which is good in hydrophilic properties, as shown in Fig. 4E. Consequently, it is possible for the ink jet recording head 55 of the present invention to have the ink brought into intimate contact with the lower surface of the vibrating plate 23, which makes it possible to properly pack or fill the pressure generating chamber 19 with ink.

[0062] On the other hand, the polymer film 13 of the high polymeric organic compound is poor in hydrophilic properties, and therefore has a water contact angle of from approximately 85 degrees to approximately 90 degrees. Consequently, when the lower surface of the polymer film 13 of the high polymeric organic compound is directly exposed to the ink in flow passages or the like, it is difficult to fill up the entire fluid circuit or flow passages with the ink, which permits air bubbles to remain in the ink received in the pressure generating chamber 19. In this case, the air bubbles in the ink of the pressure generating chamber 19 absorb the pressure pulse issued from the piezoelectric element 20, which makes it difficult for the ink ejection nozzle 41 to properly eject the ink.

[0063] In contrast to the above, in this embodiment of the present invention, since the second metallic layer 15 is formed on the lower surface of the polymer film 13 of the high polymeric organic compound by the sputtering process or by the vapor deposition process, it is possible for the vibrating plate 23 to obtain a water contact angle of from approximately 60 degrees to approximately 80 degrees which is equal to a water contact angle accomplished by the vibrating plate 23 which is entirely made of nickel.

[0064] Further, in the above embodiment, since the silicon oxide film 14 is formed on the lower surface of the second metallic layer 15 by the plasma CVD process, it is possible for the above embodiment to improve the above-mentioned water contact angle from the range of from approximately 60 degrees to approxi-

mately 80 degrees up to a range of from approximately 40 degrees to approximately 70 degrees, for example.

[0065] Further, it is also possible for the above embodiment to improve a lower surface of the silicon oxide film 14 in its hydrophilic properties by using the plasma radiation process, through which a water contact angle of from approximately 40 degrees to approximately 60 degrees, for example, may be accomplished.

[0066] In case that both the second metallic layer 15 and the silicon oxide film 14 are not formed on the lower surface of the polymer film 13 of the high polymeric organic compound, the adhesive properties of the lower surface of the polymer film 13 remain poor, which impairs bond strength between the polymer film 13 and the chamber plate 16, and also limits in choice the material of an adhesive layer disposed between the polymer film 13 and the chamber plate 16 to polyimide-based adhesives only.

[0067] However, in setting or hardening operations, the polyimide-based adhesives require a high setting or hardening temperature of more than or equal to 200 °C, which leads to the disadvantage that the components of the ink jet recording head 55 of the present invention are subjected to such a high setting or hardening temperature of the polyimide-based adhesives, thermally expanded, and therefore misaligned when assembled into the ink jet recording head 55.

[0068] In contrast to this, in the embodiment of the present invention, even when the second metallic layer 15 is directly bonded to the chamber plate 16, it is possible to obtain sufficient bond strength between the second metallic layer 15 and the chamber plate 16. Further, in bonding operations, it is possible to use epoxy-based adhesives or like adhesives, a setting temperature of which is lower than that of polyimide-based adhesives.

[0069] Further, in the above embodiment, as shown in Fig. 4D, since the silicon oxide film 14 is formed on a lower surface of the second metallic layer 15, it is possible to use epoxy-based adhesives or like adhesives as is in the case that the second metallic layer 15 is directly bonded to the chamber plate 16 without using the silicon oxide film 14.

[0070] Further, in the above embodiment, when a lower surface of the silicon oxide film 14 is activated by using the plasma radiation process, it is possible to improve the lower surface of the silicon oxide film 14 in its adhesive strength with respect to the chamber plate 16, and also possible to increase in choice the number of available adhesives.

[0071] In the above embodiment, it is possible to form the thin-walled peripheral portion 24 by etching only the first metallic layer 11 of stainless steel in the vibrating plate 23 which are provided with both first metallic layer 11 of stainless steel and the polymer film 13 of the high polymeric organic compound, wherein the thin-walled peripheral portion 24 is substantially equal in thickness to the polymer film 13 which is made of the high polymeric organic compound, as shown in Fig. 4B.

[0072] Consequently, in the embodiment of the present invention, the thin-walled peripheral portion 24 of the vibrating plate 23 increases in thickness, and is therefore improved in physical or mechanical strength when compared with the corresponding conventional construction. Due to this, the thin-walled peripheral portion 24 is improved in rigidity. As is clear from the above, it is possible to prevent the individual thin-walled peripheral portions 24 from varying from each other in resiliency in construction, which ensures that the ink is ejected from each of the ink ejection nozzles 41 under substantially the same pressure level.

[0073] Incidentally, in the embodiment of the present invention, it is also possible to directly apply the plasma radiation process to a lower surface of the second metallic layer 15 without forming the silicon oxide film 14 on the lower surface of the second metallic 15, wherein the lower surface of the second metallic layer 15 is exposed to the ink received in the pressure generating chamber 19. As a result of application of the plasma radiation process to the lower surface of the second metallic layer 15. it is possible to further improve the lower surface of the second metallic layer 15 in its hydrophilic properties.

[0074] Further, in case that the second metallic layer 15 is not used in the vibrating plate 23, it is possible to form the polymer film 13 of the high polymeric organic compound on the lower surface of the first metallic layer 11 of stainless steel which has its upper surface brought into contact with the piezoelectric element 20, and also possible to form the silicon oxide film 14 on a lower surface of the thus formed polymer film 13 of the high polymeric organic compound, as is suggested in Fig. 4E.

[0075] In this case, the silicon oxide film 14 serves as an inner surface of the vibrating plate 23, and is therefore brought into contact with the ink received in the pressure generating chamber 19. Consequently, by using the hydrophilic properties of this silicon oxide film 14, it is possible to have the ink of the pressure generating chamber 19 brought into intimate contact with the vibrating plate 23, and also possible to effectively fill or pack ink into the pressure generating chamber 19. Further, when the lower surface of the silicon oxide film 14 is activated by the plasma radiation process performed in the oxidizing atmosphere, it is possible to have the lower surface of the silicon oxide film 14 brought into more intimate contact with ink received in the pressure generating chamber 19.

[0076] In the above description, while the present invention has been particularly shown and described with reference to its preferred embodiments shown in the accompanying drawings, it will be understood by those skilled in the art that various changes and modifications in form and detail may be made therein without departing from the spirit and scope of the present invention as defined by the appended claims. Consequently, both the ink jet recording head of the present invention and the method of the present invention for manufacturing the

ink jet recording head are not limited to the preferred embodiments only, but include any changes and modifications in construction of these preferred embodiments, which changes and modifications may be made without departing from the spirit and scope of the present invention.

[0077] As is clear from the above description, the present invention has the following effects: namely, both the ink jet recording head 55 of the present invention and the method of the present invention for manufacturing this ink jet recording head 55 are capable of: realizing the effective ink filling or packing operation in the pressure generating chamber 19; realizing the excellent ink ejection operation, and thereby realizing the high quality gradation expression in printing or recording operations; and, remarkably lessening the degree of required accuracy both in dimension and in alignment of its individual components which are assembled into (i. e., stacked together to form) the ink jet recording head 55 of the present invention.

[0078] It is thus apparent that the present invention is not limited to the above embodiments but may be changed and modified without departing from the scope and spirit of the invention.

[0079] Finally, the present application claims the Convention Priority based on Japanese Patent application No. Hei 11-084062 filed on March 26, 1999, the disclosure of which is totally incorporated herein by reference.

Claims

1. In an ink jet recording head (55) comprising: a pressure generating chamber (19) communicating with an ink reservoir (40); a vibrating plate (23) which faces said pressure generating chamber (19) and is provided with an island-like convex portion (18); and, a piezoelectric element (20) which is so arranged as to be brought into contact with said island-like convex portion (18) of said vibrating plate (23) to vibrate said vibrating plate (23), and thereby forcing ink droplets to be ejected from an ink ejection nozzle (41). said ink jet recording head (55) characterized in that:

   said vibrating plate (23) is provided with a first metallic layer (11) brought into contact with said piezoelectric element (20), a second metallic layer (15) exposed to said pressure generating chamber (19), and a polymer film (13) made of a high polymeric organic compound interposed between said first metallic layer (11) and said second metallic layer (15); and
   said island-like convex portion (18) of said vibrating plate (23) is formed by etching a surface of said first metallic layer (11) .

2. The ink jet recording head (55) according to claim 1, characterized in that said first metallic layer (11) and said polymer film (13) made of said high polymeric organic compound are bonded to each other through an adhesive layer (12).

3. The ink jet recording head (55) according to claim 1, characterized in that said second metallic layer (15) is formed on said polymer film (13) of said high polymeric organic compound by a sputtering process or by a vapor deposition process.

4. The ink jet recording head (55) according to claim 1, characterized in that said first metallic layer (11) is made of stainless steel.

5. The ink jet recording head (55) according to claim 1, characterized in that said second metallic layer (15) is made of nickel.

6. The ink jet recording head (55) according to claim 1, characterized in that a silicon oxide film (14) is formed on a surface of said second metallic layer (15).

7. The ink jet recording head (55) according to claim 6, characterized in that said silicon oxide film (14) has its surface activated by a plasma radiation process performed in an oxidizing atmosphere.

8. The ink jet recording head (55) according to claim 7, characterized in that said second metallic layer (15) has a surface thereof exposed to said pressure generating chamber (19), said surface of said second metallic layer (15) being subjected to said plasma radiation process.

9. In an ink jet recording head (55) comprising: a pressure generating chamber (19) communicating with an ink reservoir (40); a vibrating plate (23) which faces said pressure generating chamber (19) and is provided with an island-like convex portion (18); and, a piezoelectric element (20) which is so arranged as to be brought into contact with said island-like convex portion (18) of said vibrating plate (23) to vibrate said vibrating plate (23), and thereby forcing ink droplets to be ejected from an ink ejection nozzle (41), said ink jet recording head characterized in that:

   said vibrating plate (23) is provided with a first metallic layer (11) having its surface brought into contact with said piezoelectric element (20), a polymer film (13) which is made of a high polymeric organic compound and formed on a lower surface of said first metallic layer (11) to have its surface exposed to said pressure generating chamber (19), and a silicon oxide film (14) formed on said polymer film (13) of said high

polymeric organic compound; and
said island-like convex portion (18) of said vibrating plate (23) is formed by etching said surface of said first metallic layer (11).

10. The ink jet recording head (55) according to claim 9, characterized in that said silicon oxide film (14) has its surface activated by a plasma radiation process performed in an oxidizing atmosphere.

11. In a method for manufacturing an ink jet recording head (55) comprising: a pressure generating chamber (19) communicated with an ink reservoir (40); a vibrating plate (23) which faces said pressure generating chamber (19) and is provided with an island-like convex portion (18); and, a piezoelectric element (20) which is so arranged as to be brought into contact with said island-like convex portion (18) of said vibrating plate (23) to vibrate said vibrating plate (23), and thereby forcing ink droplets to be ejected from an ink ejection nozzle (41), said method for manufacturing an ink jet recording head (55) characterized by comprising:

a bonding step for bonding a first metallic layer (11) and a polymer film (13) to each other, wherein said first metallic layer (11) is brought into contact with said piezoelectric element (20), while said polymer film (13) is made of a high polymeric organic compound to form a part of a thin-walled portion in a peripheral portion of said island-like convex portion (18) of said vibrating plate (23);
an island-like convex portion forming step for forming said island-like convex portion (18) of said vibrating plate (23) by etching said first metallic layer (11);
a second metallic layer forming step for forming a second metallic layer (15) on a lower surface of said polymer film (13) of said high polymeric organic compound to have a lower surface of said second metallic layer (15) exposed to said pressure generating chamber (19), wherein said polymer film (13) of said high polymeric organic compound has its lower surface positioned so as to be more distant from said first metallic layer (11) compared to its upper surface;
whereby said vibrating plate (23) is formed through said bonding step, said island-like convex portion forming step and said second metallic layer forming step.

12. The method for manufacturing the ink jet recording head (55) according to claim 11, characterized in that: in said bonding step, said first metallic layer (11) and said polymer film (13) of said high polymeric organic compound are bonded to each other through an adhesive layer (12).

13. The method for manufacturing the ink jet recording head (55) according to claim 11 or 12, characterized in that: in said second metallic layer forming step, said second metallic layer (15) is formed on said polymer film (13) of said high polymeric organic compound by a sputtering process or by a vapor deposition process.

FIG.1

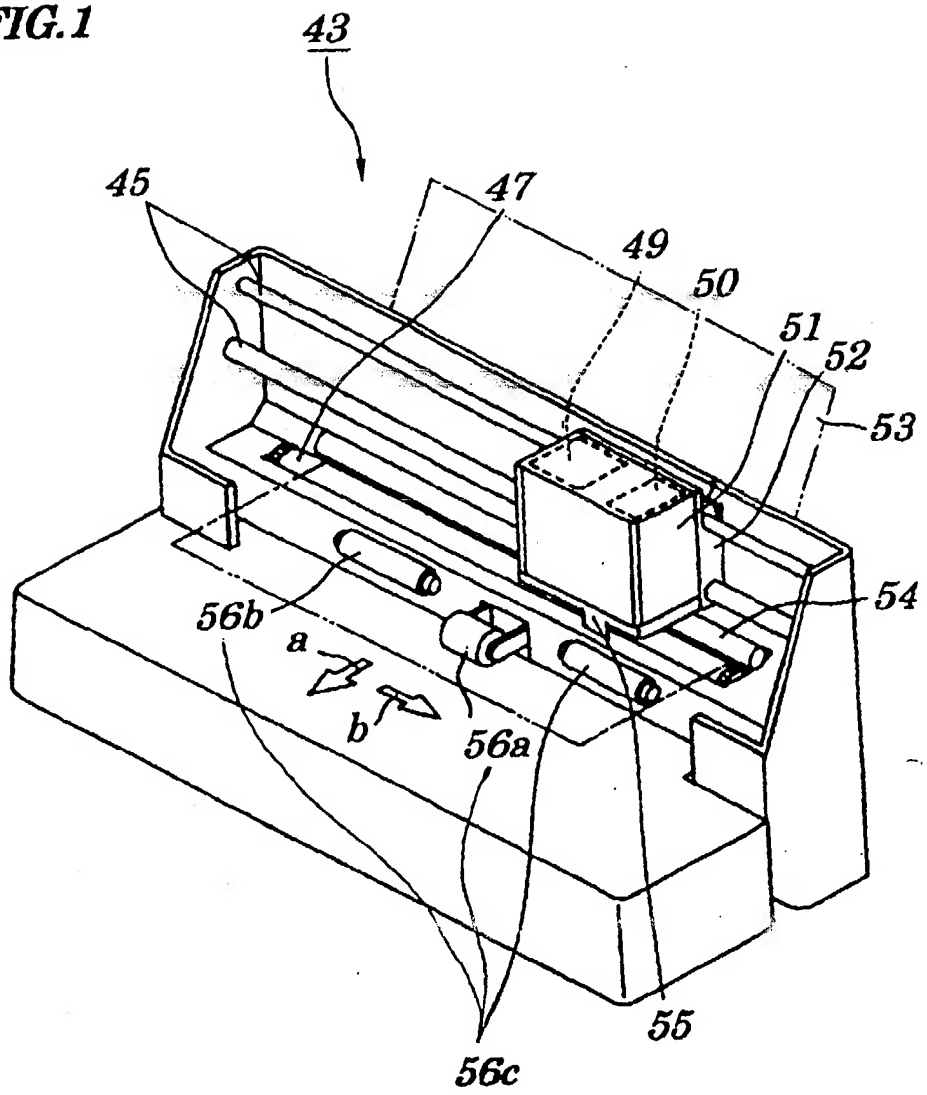
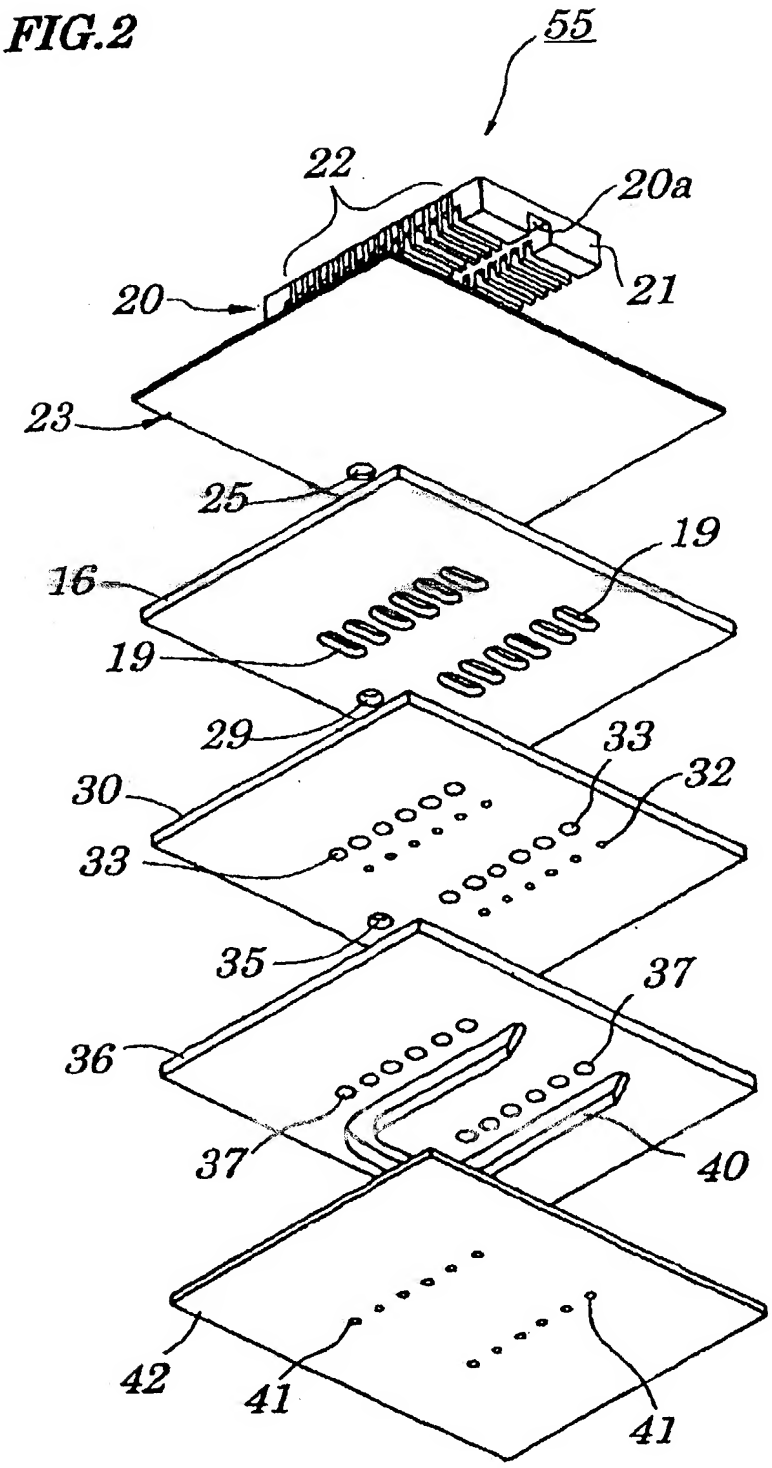


FIG.2



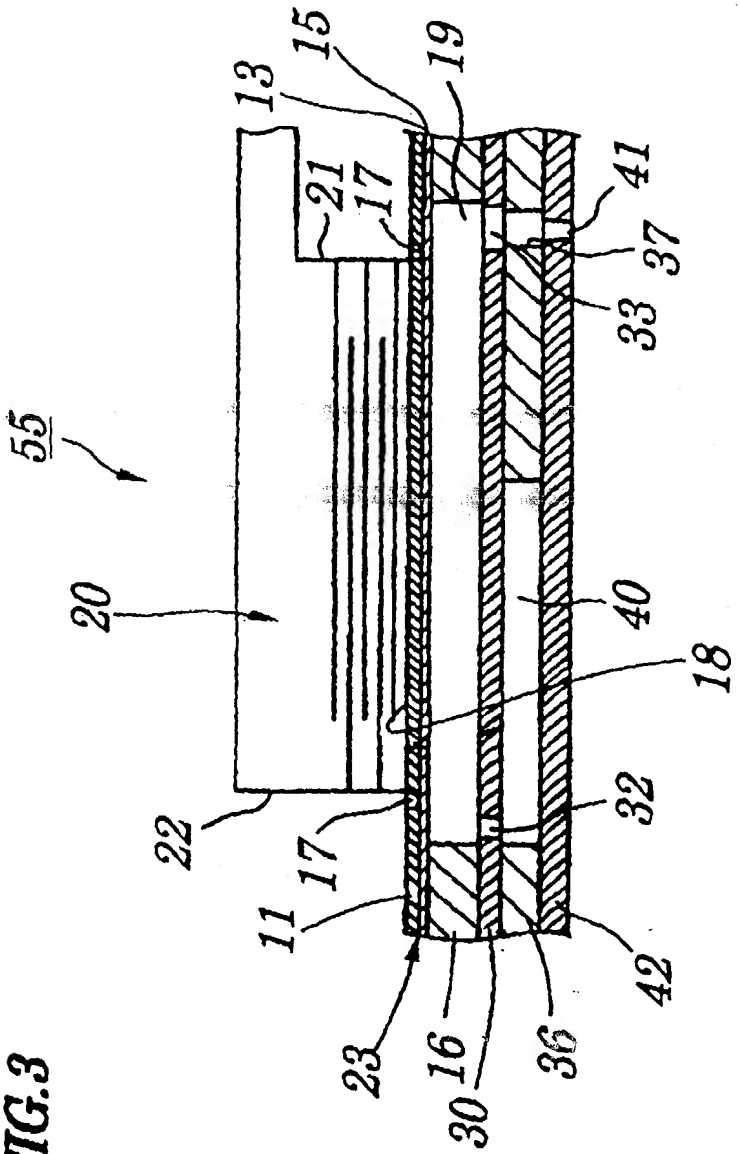


FIG.3

FIG.4A

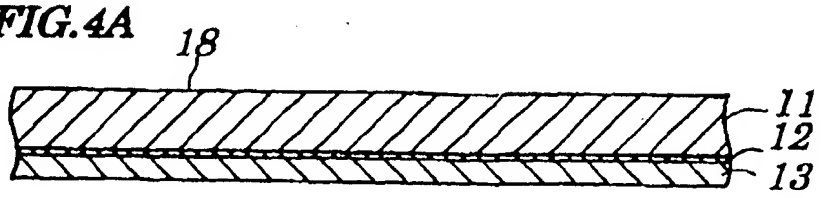


FIG.4B

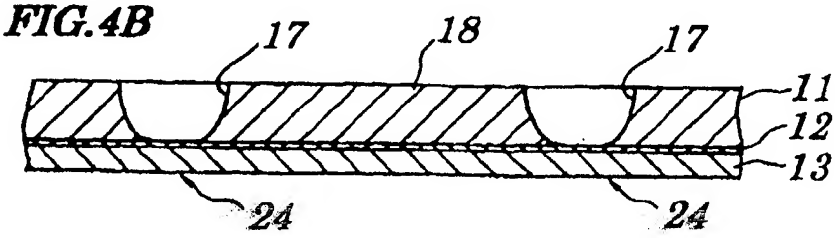


FIG.4C

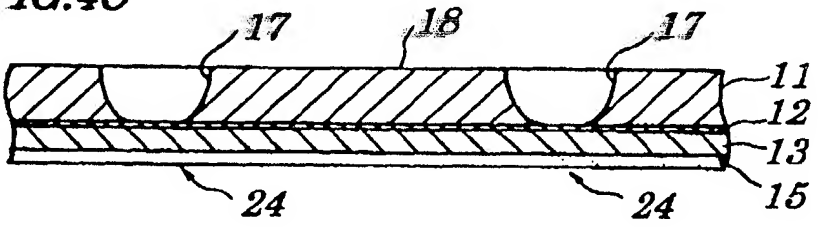


FIG.4D

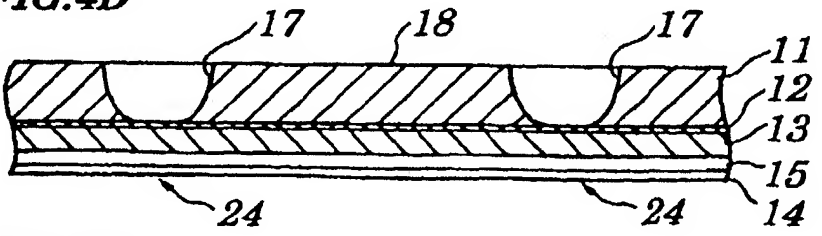
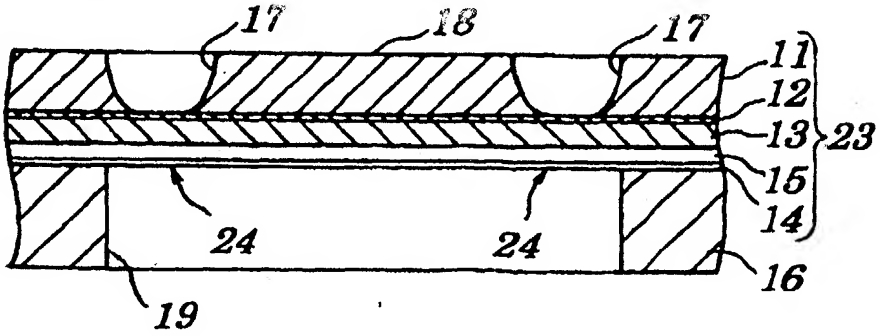


FIG.4E



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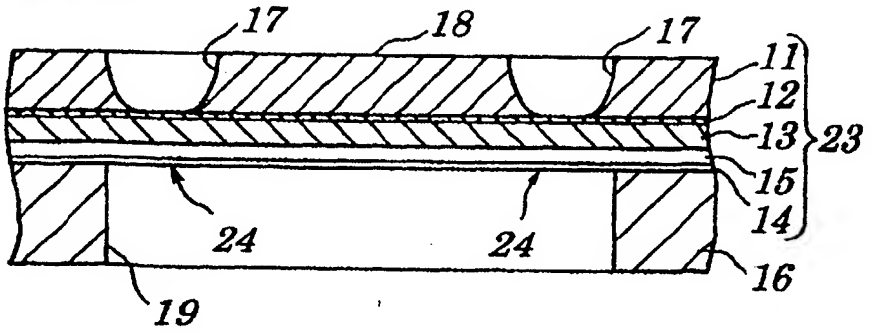
(54) Ink jet recording head and method for manufacturing the same

(57) An ink jet recording head (55) may improve the packing efficiency of the ink into the pressure generating chamber (19), and improve the ejection efficiency of the ink through the ink ejection nozzle (41) to realize a high quality gradation expression in printing operations. The recording head (55) comprises: a pressure generating chamber (19) communicating with an ink reservoir (40); a vibrating plate (23) which faces the pressure generating chamber (19) and is provided with an island-like convex portion (18); and, a piezoelectric element (20) arranged so as to be brought into contact with the island-like convex portion (18) of the vibrating plate (23) to vibrate the plate (23), and thereby forcing ink droplets to be ejected from the nozzle (41). The vibrating plate (23) comprises: a first metallic layer or stainless steel member (11) brought into contact with the piezoelectric element (20), a second metallic layer or thin nickel film(15) exposed to the pressure generating chamber (19), and a polymer film (13) of a high polymeric organic compound interposed between the first metallic layer (11) and the second metallic layer (15). The island-like convex portion (18) of the vibrating plate (23) is formed by etching a surface of the first metallic layer (11).

FIG.4E



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EUROPEAN SEARCH REPORT

Application Number
EP 00 10 6532

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THE HAGUE	15 February 2001	Verhoef, P

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